Polyelectrolyte-Surfactant Complexes (PSCs): Thin Film Morphology

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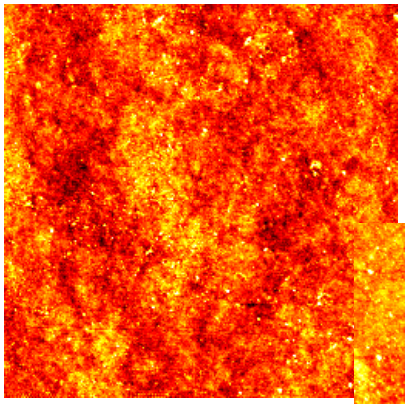
DMR-0076169

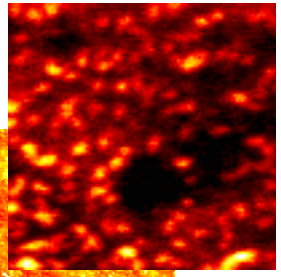
Tapping-Mode AFM

1 % C_{12}TAB

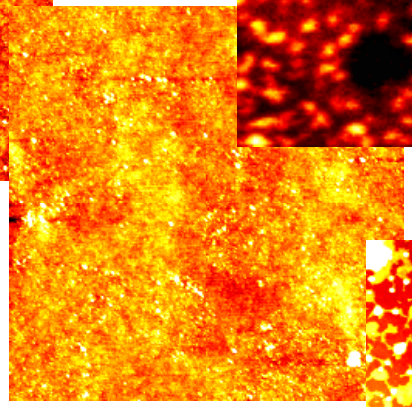


Fluorescence NSOM

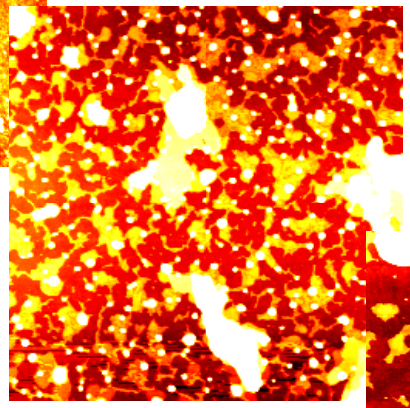
1 % DiI



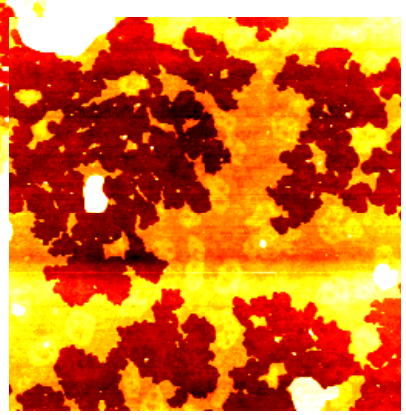
10 % C_{14}TAB



25 % C_{16}TAB



50 % C_{18}TAB



Materials (PSCs):

These materials are formed by complexing ionic surfactants such as the alkyltrimethyl-ammonium bromides with oppositely-charged surfactants such as poly(vinyl sulfate). For optical imaging studies, fluorescent surfactants are also employed, these include an indocarbo-cyanine dye known as (DiI). When spin cast, morphologically complex films result.

Goals/Results:

We seek a better understanding of PSC film nanoscale morphology. As the surfactant species and surfactant content of the PSCs are changed, a dramatic evolution from uniform films, to films containing small PSC micelles, and finally to films containing PSC bilayer phases are observed. Diverse film morphology plays a critical role in governing PSC film solubility and its ability to adsorb ionic species, including small ions, proteins and DNA.

Xiangmin Liao and Daniel A. Higgins, Langmuir, **2002**, *18*, 6259.
Xiangmin Liao and Daniel A. Higgins, Langmuir, **2001**, *17*, 6051.

Critical Casimir Force

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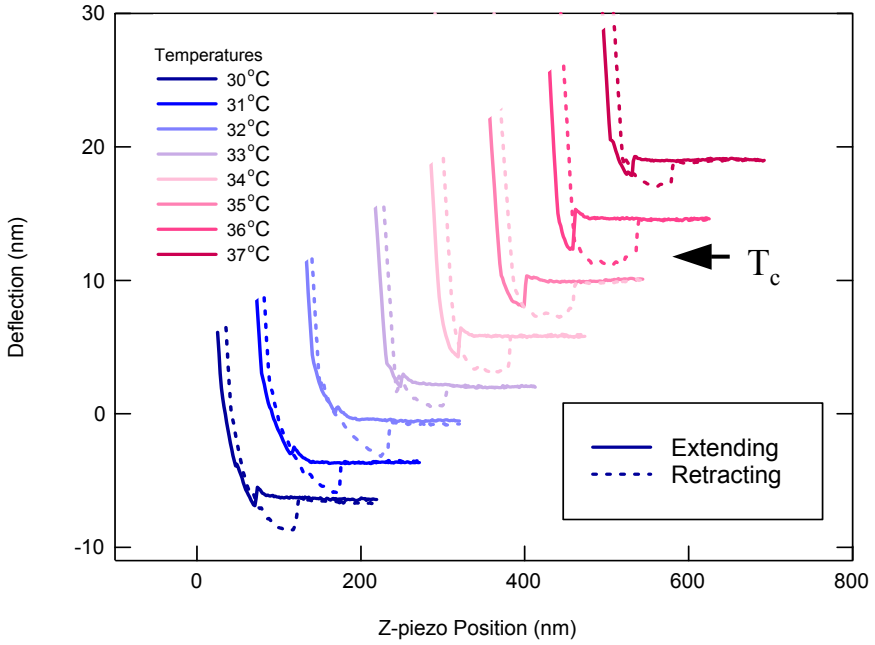
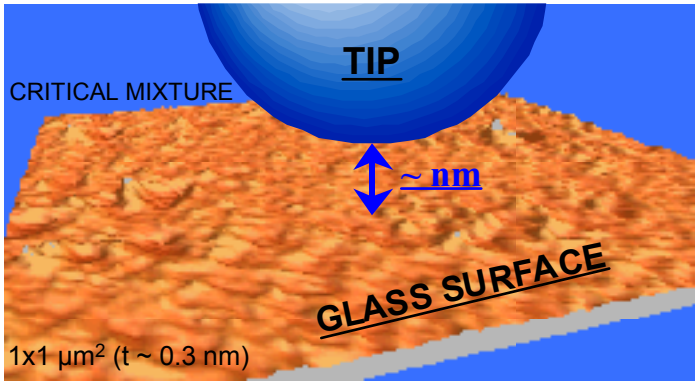
DMR-0076169

When electromagnetic fluctuations are confined in vacuum between two uncharged metallic surfaces, this confinement gives rise to a force called the Casimir force. An analogous force, called the Critical Casimir Force, also arises in critical binary liquid mixtures when the composition fluctuations, which diverge on approaching the mixture's critical temperature (T_c), are confined by the presence of two hard walls. This force can be measured using an Atomic Force Microscope on approaching a surface, if immersed in a critical liquid mixture.





Figures

[Above] Comparisons of force-vs.-distance curves at various temperatures (T_c ~ 35.6°C) in the critical binary liquid mixture 2,6-lutidine + water, with a bare silicon nitride tip and glass surface. The preliminary (extending) data provide evidence for the critical Casimir force, indicated by the larger jump in distance, near T_c (arrow inset).

[Left] Illustration of the geometry of the two boundaries for a glass and tip surface in a critical liquid mixture. The glass surface was imaged using an Atomic Force Microscope and shows 0.3 nm maximum surface roughness in a size of 1x 1 μm².

Characterization of Sol-Gel Derived Silicate Films

Maryanne M. Collinson, Department of Chemistry, Kansas State University

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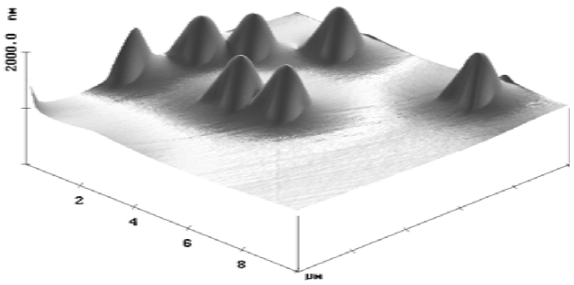
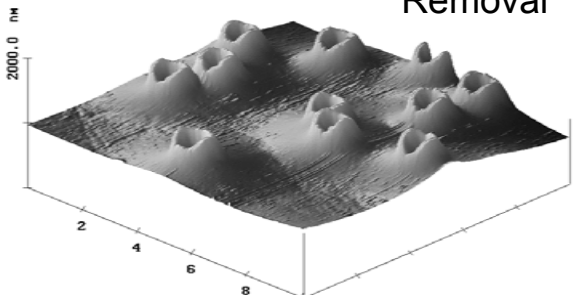
The atomic force microscope has been used to evaluate the surface morphology of silicate films prepared via the sol-gel process. The results from these experiments are compared with electrochemical data and used to understand the microstructure of these important materials.

The size and distribution of template (1 μm polystyrene latex spheres) induced pores in the silicate framework has been characterized using AFM. (*Chem Comm* 2001; *Langmuir* 2001)

Before Template Removal

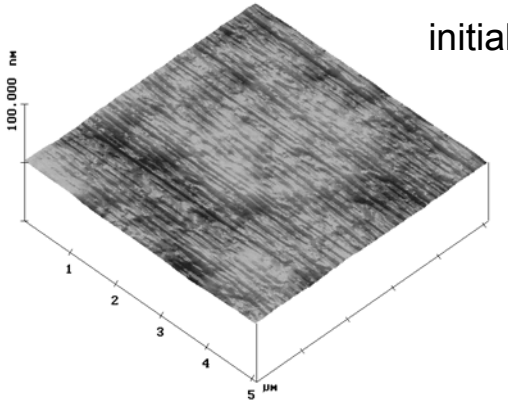


After Template Removal

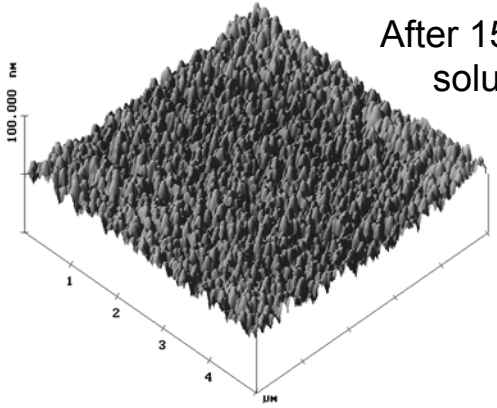


The stability of silicate films in solution has been assessed using AFM. The films are much more porous after being in solution for extended periods of time (*J. Electroanal. Chem.* 2002)

initial



After 150 hr in solution

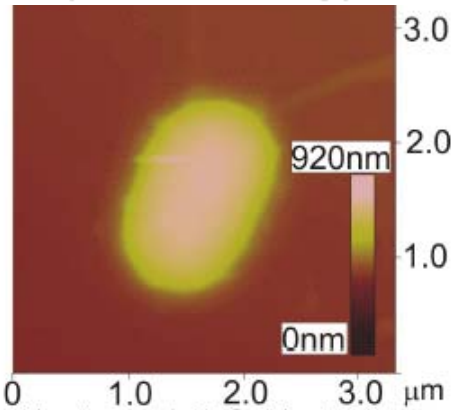


DMR-0076169

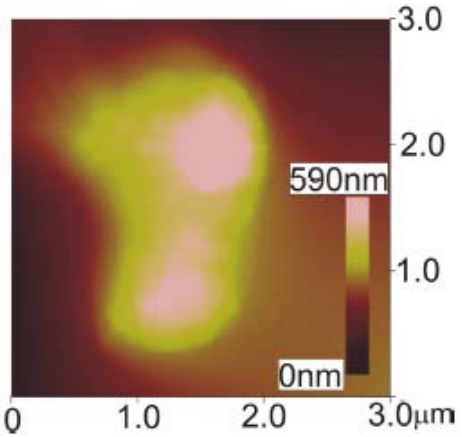
Examination of bactericidal activity of nanomaterials

Peter K. Stoimenov, Kenneth J. Klabunde, George L. Marchin
Kansas State University, Departments of Chemistry and Biology

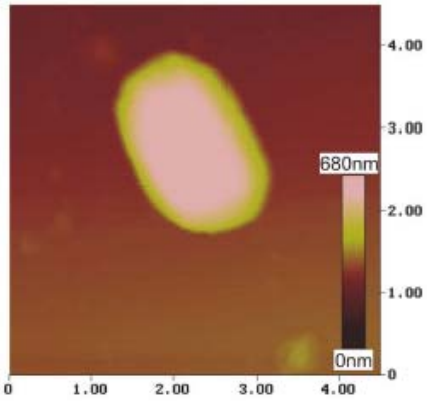
— The aim of the work is to elucidate how very small particles called 'nanoparticles' interact with bacteria and spore cells.
— Nanomaterials are found to possess physical and chemical properties, which are distinctive compared to those of the bulk material.
— Bacteriological tests have shown that nanoparticles of magnesium oxide with mean diameter of 4 nm and their halogen adsorbate derivatives have very distinctive bactericidal and sporicidal properties.
— AFM confirms that very significant changes take place in the shape and morphology of the cells.



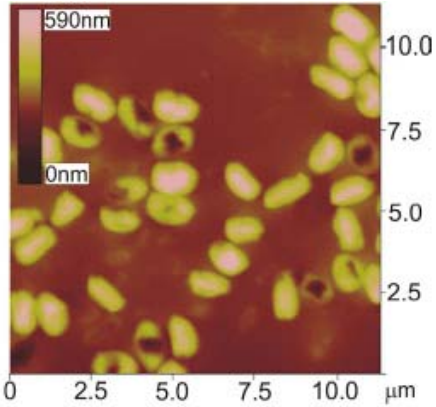
Non treated *E. Coli* bacterium



E. Coli cells treated with $MgO.Cl_2$ nanoparticles



Non treated *B. Subtilis* spore cell



B. Subtilis spore cells treated with $MgO.Cl_2$ nanoparticles

Stoimenov at al., Langmuir, **18**, (2002), 6679-6686

DMR-0076169

Research on self-assembled gold nanoparticles

Savka Stoeva, Peter Stoimenov, B. Prasad, Kenneth Klabunde, Christopher Sorensen

Kansas State University, Departments of Chemistry and Physics

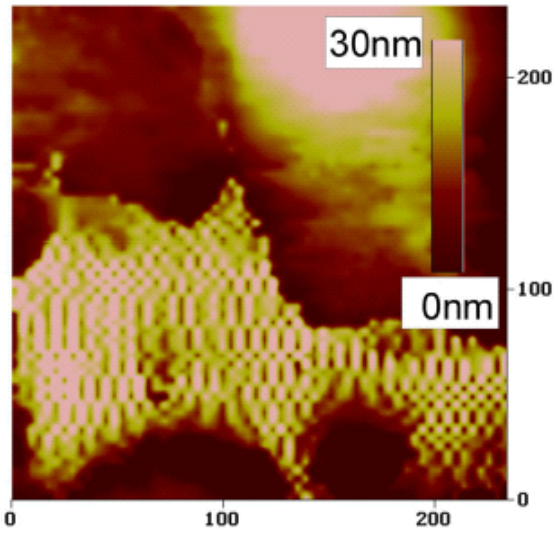
—It is to be expected that creation of monodispersed nanosized particles will lead to their self assembly in a regular lattice ('superlattice') such as atoms do in a crystal.

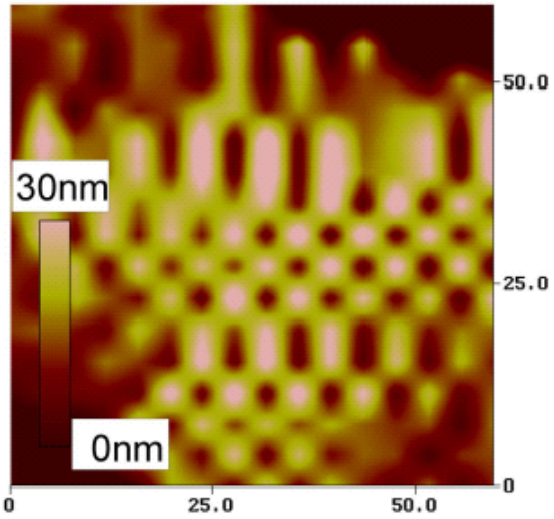
—TEM studies have confirmed that close to the edges of nanoparticle aggregates, the nanoparticles are assembled in a regular crystal supperlattice. However the TEM cannot examine the surface of the aggregates.

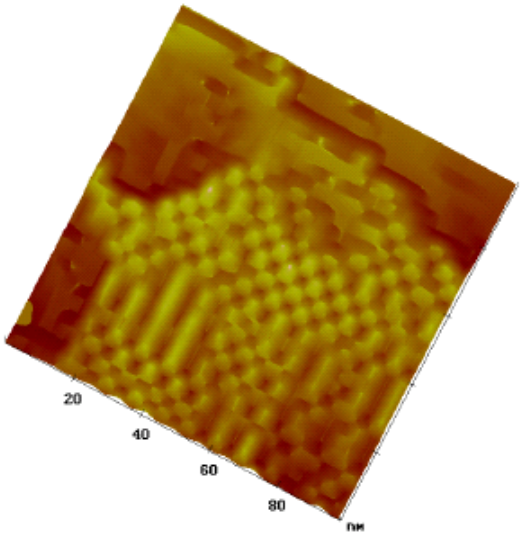
—AFM allows the investigation of the surface of the aggregates. It confirms that the structure on the edges and on the surface of the aggregates is identical.

—AFM provides the opportunity to study the self-assembly process on a variety of supports, which is impossible by other techniques.

—The measured interparticle distances, as well as the nanoparticles superlattice structure is in excellent agreement with the results from HRTEM and XRD.







Education, Outreach, Mentoring

DMR-0076169

The state-of-the-art Scanning Probe Microscope (SPM) purchased under this grant has served as a valuable tool for the training of:

√ Nine Graduate Students

These students, who use the system extensively (6 hrs/week or more), come from research groups in Chemistry (6), Physics (1), Chemical Engineering (1), and Biochemistry (1).

√ Three Postdoctoral Associates

These have come from groups in Chemistry and Physics.

√ Two Undergraduate Students

These students were supported by our NSF-REU grant. The students received training in SPM methods over the summers of 2001 and 2002. They had few, if any opportunities to use such sophisticated instrumentation in their home institutions.

The SPM has been employed in part for research tied to industrial funding and collaborations. These include collaborations with:

√ 3M Company - Characterization of Liquid Crystal Composites

√ Luxfer - Characterization of Metal Surfaces and Coatings

√ NanoScale Materials - Characterization of Metal Oxide Nanoparticles